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AQUATIC PHYCOMYCETES OF LILY LAKE, UTAH[1]

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ABSTRACT.— During the ice-free period from May to November on two successive summers water molds were collected on 14 different substrata placed in Lily Lake, a subalpine bog lake in the Uinta Mountains of Utah. Twenty-five collections yielded thirty-four species in 20 genera, 11 families, and 6 orders of aquatic Phycomycetes. Correlation of frequency presence of the species reported with physical and chemical characteristics of the lake showed that the number of species collected increased with an increase in water temperature and a decrease in oxygen content during June to August, reaching a peak in late July. *Rhipidium americanum Thaxter* (100 percent frequency) and *Sapromyces androgynus* Thaxter (72 percent frequency) were the most common species and the species found on more different substrata than any others. Also in the "very abundant" group were *Saprolegnia ferax* (Gruith.) Thurent and *Achlya* sp., both with 64 percent frequency.

Lily Lake, a subalpine lake in the Wasatch National Forest of the Uinta Mountain region, Utah, is located about one-half mile west of Trial Lake at an elevation of 10,000 feet (T. 3, R. 9 E., sec. 31). This lake, which is one of the acidic, cold, lentic bogs characteristic of the area, is the site of a taxonomic-distribution study of aquatic Phycomycetes. This study is a beginning to our understanding of the role of fungi in Lily Lake, and it supplies the first information on record of the water molds of this area. Fungi found on 14 different substrata are identified and correlated with pH, dissolved oxygen, and temperature of the lake.

Christensen and Harrison (1961) have described the psysiography and possible plant succession around Lily Lake. Stutz (1951) studied the hydrarch succession as well as physical and chemical properties of water and soil at Moss Lake, a similar subalpine lake in the Granddaddy Lake Basin nearby. Tanner (1931) reported on the algae of the Mirror Lake region in the Uinta Mountains.

Little is known about the fungi in subalpine lakes. However, Tiesihausen (1912) and Rutter (1937) reported on the alpine water molds of the Swiss Alps. Koob (1966) reported *Rhizophidium plank-*

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tonicum Canter on *Asterionella formosa* Hauss. in subalpine lakes of Colorado. Studies by Chapman (1965), Coker (1923), Jewell and Brown (1929), and Willoughby (1961) report fungi in bogs, and there are a few papers showing seasonal distribution of aquatic Phycomycetes: Coker (1923), Suzuki (1960, 1961), and Willoughby (1962).

Water molds are given little consideration in general treatments of aquatic ecology (Welsh, 1945; Weston, 1941). However, representatives of these fungi have been found in all types of inland waters that have been studied for them (Crooks, 1938; Graff, 1928; Johnson, 1956; Koob, 1966; Sparrow, 1960; Suzuki, 1960a, 1961a; Suzuki and Nimura, 1960, 1961). As saprophytes and parasites on aquatic plants and animals, they are important in biological interactions in lakes.

Methods and Materials

At approximately weekly intervals during the study period, water molds were collected and environmental data of the water were recorded. Baits were placed in the lake during the ice-free period from May 1965, to November 1965, and from May 1966, to June 1966. The 14 substrata used for bait may be classified in four major groups as follows: (i) twigs (river birch, weeping white birch, poplar, hackberry, pine); (ii) fruits (apples, rose hips); (iii) chitinous and keratinous materials (human hair, snake skin, insect exuviae); and (iv) miscellaneous materials (cellophane, *Ulothrix*, pine pollen, pine needles). Of these, the twigs and fruits were collected in the autumn preceding their use and stored at 5 C until needed.

A wire basket containing the baits was placed 1½ feet below the surface of the lake each week and removed four weeks later. When removed from the lake the basket was transferred to a glass jar and brought to the laboratory, where the baits were rinsed with tap water and examined for aquatic Phycomycetes. Both temporary water mounts and permanent mounts were prepared for microscopic examination of the fungi. After this initial examination the baits were cultured in large plastic dishes, using water collected that week from the lake. Such additional substrata as human hair, pine pollen, and insect exuviae were added to the cultures, which were then covered with a glass plate and cultured at 5 C. These cultures were examined three to seven days later for chytrids and other microscopic species.

For any one collection, species of Phycomycetes were listed simply as present or absent, and no attempt was made to estimate the number of thalli; therefore, a record of presence may refer to a single thallus or a great number of thalli. The term *frequency*, as used in this study, refers to the number of times the species occurred in 25 collections and is expressed as a percentage. For example, *Rhipidium thaxteri* Minden occurred seven times in 25 collections and has a frequency of 28%.

Water temperature, pH, and dissolved oxygen were measured on each visit to the lake. The pH was measured in the field with a Beckman pH meter, Model G, except on July 29 and August 8, 1965, when it was measured with a Beckman Model K pH meter in the laboratory. Dissolved oxygen was measured with a Yellow Spring Instrument Model 51 oxygen meter.[1]

Results

Thirty-four species representing 20 genera, 11 families, and 6 orders of aquatic Phycomycetes were obtained from the 25 collections made from Lily Lake during the course of this study. On the basis of frequency, each species is placed in one of four groups as follows (Table 1): (i) very abundant (frequency 64-100%)—4 species; (ii) moderately abundant (frequency 20-36%)—10 species; (iii) occasional (frequency 12-20%)—5 species; and (iv) scarce (occurred only once or twice)—15 species.

Table 2 shows the number of species in each order and the substrata on which each species occurred. Identification of the 11 species of Saprolegniales made this order the most widely represented among the orders studied. However, they were not the most abundantly occurring species on substrata of categories (i) twigs, (ii) fruits, or (iii) chitin-keratin. Seven species of Leptomitales were found on twigs, fruits, pine needles, and insect exuviae. The Chytridiales had six species occurring on keratin, chitin, cellophane, *Ulothrix*, and pine pollen. Four species of Blastocladiales, four species of Monoblepharidales, and two species of Peronsporales were found on twigs and fruits.

The pH of the lake remained acidic throughout the study, with an average pH of 6 and a range of 5.4 to 6.5; dissolved oxygen content had an average of 7.2 ppm and a range of 5.5 to 9.2; and water temperature ranged from 0 C to 18 C for the 1965 season (Figure 1).

Discussion

The 34 species found in this study indicate that many fungi can grow under the environmental conditions of this subalpine lake, and their abundance indicates that they may be important in the biological degradation of substrata in these areas.

Since a record of species presence in this report might refer to a single thallus or, in other cases, to a great many thalli, erroneous conclusions could result. However, although no counts were made showing the number of individuals present, we noticed that species for which a high frequency was recorded were generally very abundant whenever found. The species for which a low frequency was recorded were often represented by few individuals at the time of collection. These species grew very sparsely on the bait, and there was a considerable likelihood that some were overlooked. They were seen on only a few occasions in a large number of collections.

The species in the "very abundant" and "moderately abundant" groups were saprophytes and parasites on a wide range of substrata.

[1]Mention of a trademark name or a proprietary product does not constitute a guarantee or warranty of the product by the USDA and does not imply its approval to the exclusion of other products that may also be suitable.

TABLE 1. Species found in relation to date of collection and abundance.

Species	Frequency	Date of Collection 1965 M. June			July					August				September				October					1966 M. June			
		18	10	24	1	8	15	22	29	6	13	20	27	3	10	17	24	1	8	18	22	29	5	12	19	27
Very Abundant Species																										
Rhipidium americanum	100	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Sapromyces androgynus	72		x		x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x					x
Achlya sp.	64				x	x	x	x	x	x	x	x	x	x	x	x	x	x		x		x				
Saprolegnia ferax	64				x	x	x	x	x	x	x	x	x	x	x		x	x		x	x					x
Moderately Abundant Species																										
Rhipidium interruptum	36						x	x	x	x		x				x	x		x				x			
Blastocladia pringsheimii	32			x		x			x		x	x			x				x						x	
Saprolegnia delica	28						x		x	x	x	x					x				x					
Gonapodya polymorpha	24				x								x					x						x	x	x
Pythiopsis cymosa	24				x				x	x			x	x						x						
Pythium sp.	24						x			x		x						x						x		x
Saprolegnia hypogyna	24							x		x	x			x			x		x							
Phytophthora sp.	20							x	x			x					x	x								
Rhipidium thaxteri	20					x	x					x	x				x									
Sapromyces elongatus	20							x		x			x				x	x								
Occasional Species																										
Blastocladia ramosa	16			x															x						x	x
Achlya americana	12										x					x	x									
Achlya oblongata	12								x	x			x													
Chytridium acuminatum	12													x			x	x								
Gonapodya prolifera	12			x			x		x																	

TABLE 1. (Continued).

Scarce Species																										
Achlya klebsiana	8									x	x															
Blastocladia sp.	8																								x	x
Leptolegniella keratinophilum	8			x																			x			
Leptolegneilla sp.	8					x																		x		
Leptomitus lacteus	8							x	x																	
Monoblepharis polymorpha	8																						x	x		
Apodachlya brachynema	4																				x					
Blastocladia angusta	4																								x	
Megachytrium westonii	4										x															
Monoblepharis insignis	4																								x	
Nowakowskiella ramosa	4																							x		
Olpidium endogenum	4						x																			
Olpidium pendulum	4								x																	
Protoachlya paradoxa	4							x																		
Rhizophlyctis rosea	4											x														
Number of species collected per week		1	2	5	6	7	10	10	13	12	10	11	9	7	5	5	12	9	5	5	5	2	4	6	7	7

TABLE 2. Water molds of Lily Lake and the substrata on which they occurred.

Species	Substrata
Chytridiales	
Olpidiaceae	
Olpidium endogenum (Braun) Schroeter	insect exuviae, pine pollen
Olpidium pendulum Zopf	algae
Rhizidiaceae	
Rhizophlyctis rosea (de Bary and Woronin) Fischer	cellophane
Chytridiaceae	
Chytridium acuminatum Braun	cellophane, *Ulothrix*, baby hair, pine pollen
Megachytriaceae	
Nowakowskiella ramosa E. J. Butler	cellophane
Megachytrium westonii Sparrow	*Ulothrix*
Blastocladiales	
Blastocladiaceae	
Blastocladia sp.	apples
Blastocladia ramosa Thaxter	weeping white birch twigs, apples
Blastocladia angusta Lund	weeping white birch twigs, rose hips
Blastocladia pringsheimii Reinisch	apples, rose hips, twigs of river birch and poplar
Monoblepharidales	
Gonapodyaceae	
Gonapodya polymorpha Thaxter	hackberry twigs, rose hips
Gonapodya prolifera (Cornu) Fischer	apples
Monoblepharidaceae	
Monoblepharis insignis var. *insignis* Thaxter	poplar twigs, apples
Monoblepharis polymorpha Corne	poplar twigs
Saprolegniales	
Saprolegniaceae	
Phythiopsis cymosa	apples, pine needles, twigs of river birch, poplar and hackberry
Saprolegnia delica Coker	apples, rose hips, insect exuviae, twigs of river birch, poplar, and hackberry
Saprolegnia ferax (Gruith.) Thurent	hackberry twigs, apples
Saprolegnia hypogyna Pringsheim	twigs of river birch and hackberry
Leptolegniella sp.	river birch twigs
Leptolegniella keratinophilum Huneycutt	river birch twigs
Protoachlya paradoxa Coker	poplar twigs
Achlya sp.	apples, insect exuviae, twigs of river birch, poplar, and hackberry
Achlya klebsiana Pieters	twigs of river birch, poplar, and hackberry
Achlya oblongata de Bary	twigs of river birch and poplar
Achlya americana Humphrey	poplar twigs
Leptomitales	
Leptomitaceae	
Leptomitus lacteus (Roth) Agardh	hackberry twigs, apples, insect exuviae
Apodachlya brachynema (Hildeb.) Pringsh.	river birch twigs

TABLE 2. Continued

Rhipidiaceae	
Rhipidium americanum Thaxter	apples, rose hips, pine needles, twigs of river birch, weeping white birch, poplar, hackberry, and pine
Rhipidium interruptum Cornu	poplar twigs, apples
Rhipidium thaxteri Minden	pine twigs, apples, pine needles
Sapromyces androgynus Thaxter	apples, twigs of river birch, weeping white birch, poplar, hackberry, and pine
Sapromyces elongatus (Cornu) Coker	rose hips, pine needles, twigs of poplar and pine
Peronosporales	
Pythiaceae	
Pythium sp.	apples, twigs of river birch, poplar, hackberry, and pine
Phythophthora sp.	apples, rose hips

By comparison, the "occasional" and "scarce" groups were usually specific saprophytes and parasites on a limited range of substrata. The greater numbers of species present during the peak periods might be a function of abundance and quality of substrata as well as physical factors of the lake. Thus, abundance of such naturally occurring substrata as lily pads, algae, and pine pollen available in June, July, and August could account for the presence of some species which were not found in May, September, and October, when the substrata were limited or absent.

The number of species collected increased with an increase in water temperature and a decrease in oxygen content during June to August, as illustrated in Figure 1. The number of different species collected was highest in the month of July 1965, and lowest in May of 1965.

Aspects of the physical environment measured may account in part for seasonal population fluctuations, but other factors may also influence them. For example, these fungi seem to infect substrata with rough surfaces or with broken or decomposed protective outer layers. Thus *Rhipidium americanum* Thaxter infected pine needles only after the cuticle of the pine needle was decomposed or cracked, calling to mind Emerson's report (1951) that in 9-11 days *Blastocladia* infected apples that were wiped with ether but took several weeks to infect untreated apples.

The two families of Leptomitales both have representatives occurring in Lily Lake. However, the species of Leptomitaceae found in this study were in group iv (scarce) as opposed to species of Rhipidiaceae, which were all in groups i and ii (abundantly to very abundantly occurring). Five species in the Rhipidiaceae had a higher percentage of occurrence than those of any other family reported in this study (Table 1). *Rhipidium americanum* was the most common species, being found in every week of the study period, and *Sapromyces androgynus* Thaxter was the second most common.

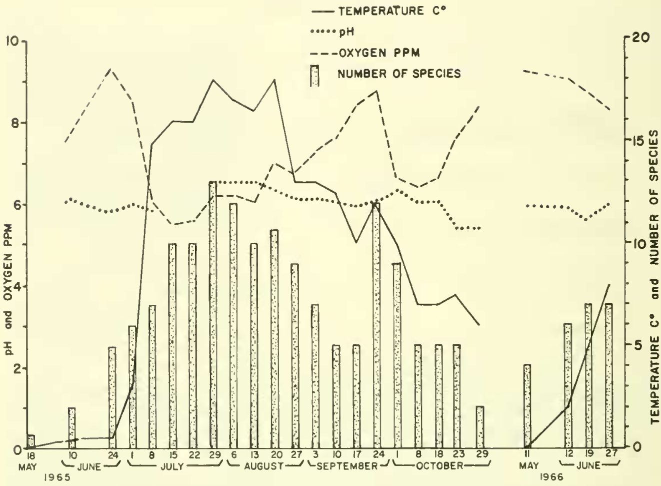

Fig. 1. Weekly comparisons of water temperature, pH, and dissolved oxygen in relation to numbers of species.

These two species were found on more different substrata than any of the others. The other two species in the "very abundant" group are *Saprolegnia ferax* (Gruith.) Thurent and *Achlya* sp., both of the Saprolegniaceae. The same two families dominate the "moderately abundant" group. There were two species of the Pythiaceae, namely, *Pythium* sp. and *Phytophthora* sp., while the Blastocladioceae is represented by *Blastocladia pringsheimii* Reinsch and the Gonapodyaceae is represented by *Gonapodya polymorpha* Thaxter. Six species of Chytridiales were collected from the lake, all in the "scarce" and "occasional" groups. However, our choice of baits and sampling techniques very likely selected against the detection of many chytrid species. Six species were found on substrata not mentioned by Sparrow (1960). These are: *Megachytrium westonii* Sparrow, parasitic on *Ulothrix; Rhizophlyctis rosea* (deB. and Wor.) Fischer, on cellophane and *Oedogonium* sp.; *Chytridium acuminatum* Braun, parasitic on pine pollen; *Monoblepharis insignis* Thaxter, saprophytic on poplar twigs and apples; and *Rhipidium americanum* and *Rhipidium thaxteri*, saprophytic on pine needles.

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